Agency Performance Measures Committee and CALFED Bay-Delta Program

Performance Measures Workshop

Tuesday, October 23, 2007

650 Capitol Mall, 5th Floor
Delta Room

Performance Measures Workshop

Tuesday, October 23, 2007

Welcome

Performance Measures Workshop

Agenda

***When*: Tuesday, October 23rd**
***Where*: Delta Room, 650 Capitol Mall, fifth floor**

~8:30 – 8:55: Refreshments~

1. 8:55 - 9:00: Call to Order and Welcome: Bill Foster
2. 9:00 – 9:15pm: Keynote Address (Joe Grindstaff)
3. 9:15 – 9:45 pm: Long-Term Vision for Performance Measures: An Adaptive Management Framework for CALFED (Michael Healey)
4. 9:45 – 10:15: Definitions – Framework and Conceptual Models (Lauren Hastings)

~15 minute break~

5. 10:30 - 10:50: Overview of Phase ll (Elizabeth Soderstrom)
6. 10:50-11:30: Performance Measures Subgroups: Where We Are and How We Got There (Paul Massera, Mike Mirmazaheri, Karen Larsen, Steve Detwiler)
7. 11:30 – 12:30: ISB Response Panel (Jack Keller, Duncan Patten, Bill Glaze)
8. 12:30 – 1:30 Lunch
9. 1:30 – 2:00: Beyond CMARP (Sam Luoma)
10. 2:00 – 2:30: Spatial Analysis and Its Role in Performance Measures (Paul Smith)

~15 minute break~

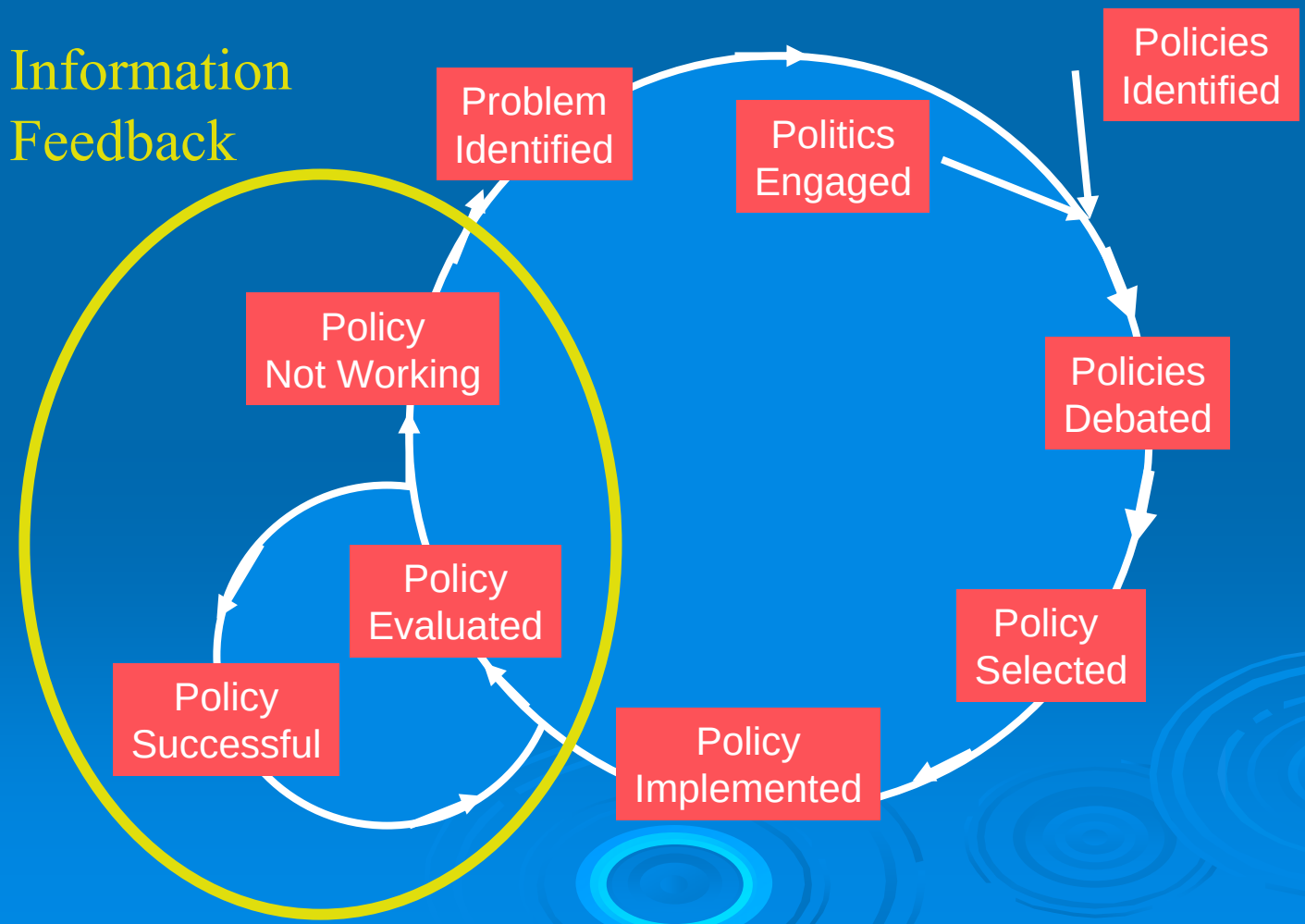
11. 2:45 – 4:15 Data Collection, Analysis and Reporting Break-Out Groups
12. 4:15 – 4:50 Report of Break-Out Groups and Close

Long-Term Vision for Performance Measures: An Adaptive Management Framework for CALFED

Dr. Michael Healy

CALFED Lead Scientist

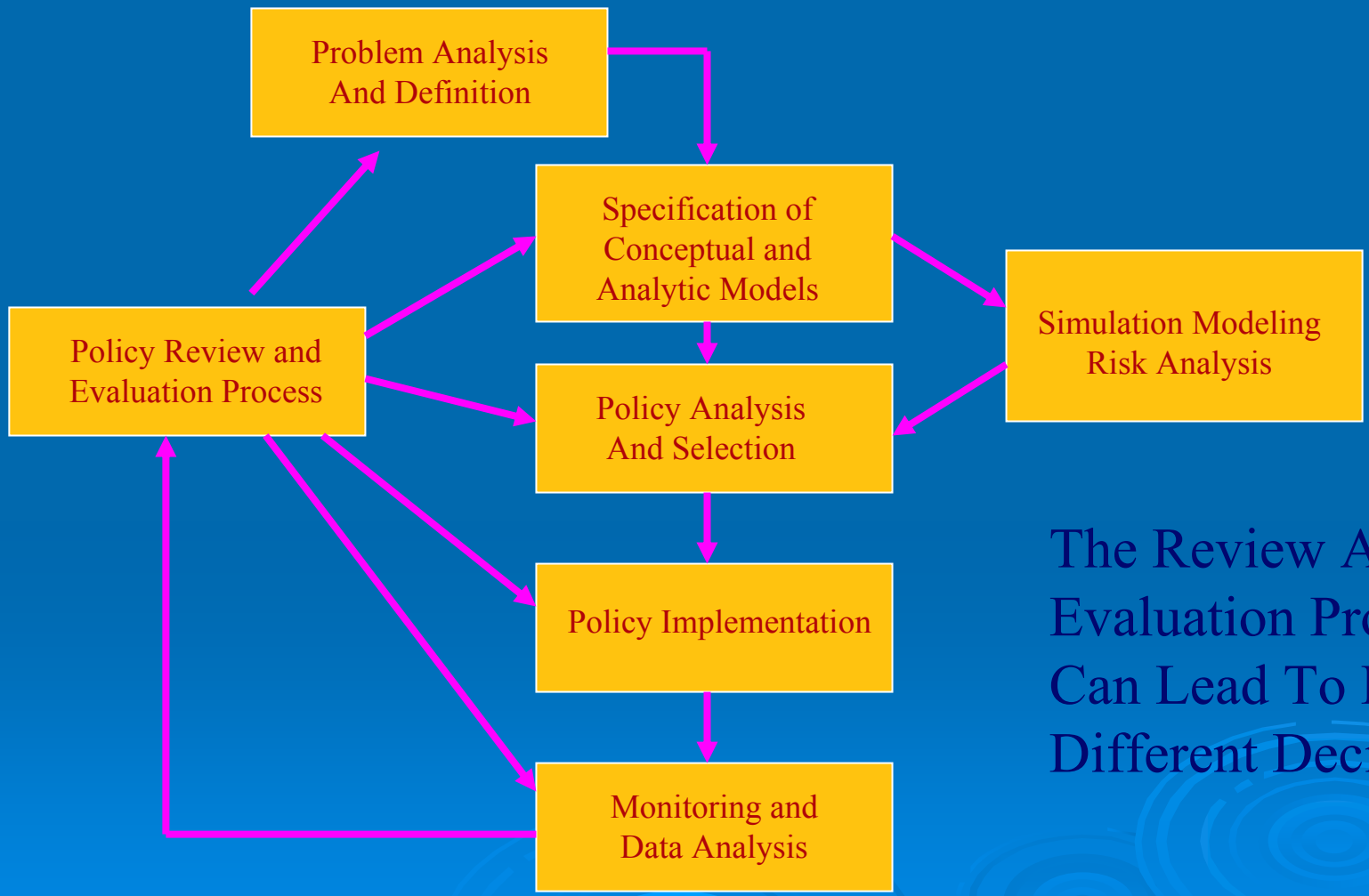
The Policy Cycle



Policy Assessment

- A Process of Information Feedback From Policy or Program Implementation to Decision-Making
- Can be Ad-hoc and Haphazard
- In Adaptive Management this is a Planned Process
- Effective Monitoring, Analysis and Evaluation are Critical to the Adaptive Process.

The Adaptive Management Cycle



The Review And Evaluation Process Can Lead To Many Different Decisions

Policy Assessment For Different Purposes

- Levels Within the Organization
  - Highly aggregated at senior management
  - More detailed at lower levels
- Assessment for Different Purposes
  - For budgetary compliance
  - For program and project assessment
  - For assessing progress toward specified goals
- Integration Among Assessments

The Paradox of Performance Assessment

- "Every one complains about the weather but no one does anything about it" *(Mark Twain)*
- "Insanity consists of doing the same thing over and over but expecting a different result" *(Albert Einstein)*
- "When presented with new facts, sir, I change my mind. What do you do, sir, with new facts?" *(??)*

Performance Assessment is like Cod Liver Oil…..

- Strengthens program and project design
- Provides opportunity to learn while doing
- Promotes objective evaluation of program performance
- Permits the most timely decisions about policy and program performance
- Seems like a pain in the A.. But is more likely to save your A..

Definitions – Framework and Conceptual Models

CALFED Performance Measures *Rally*
October 23, 2007
Lauren Hastings
CALFED Science Program

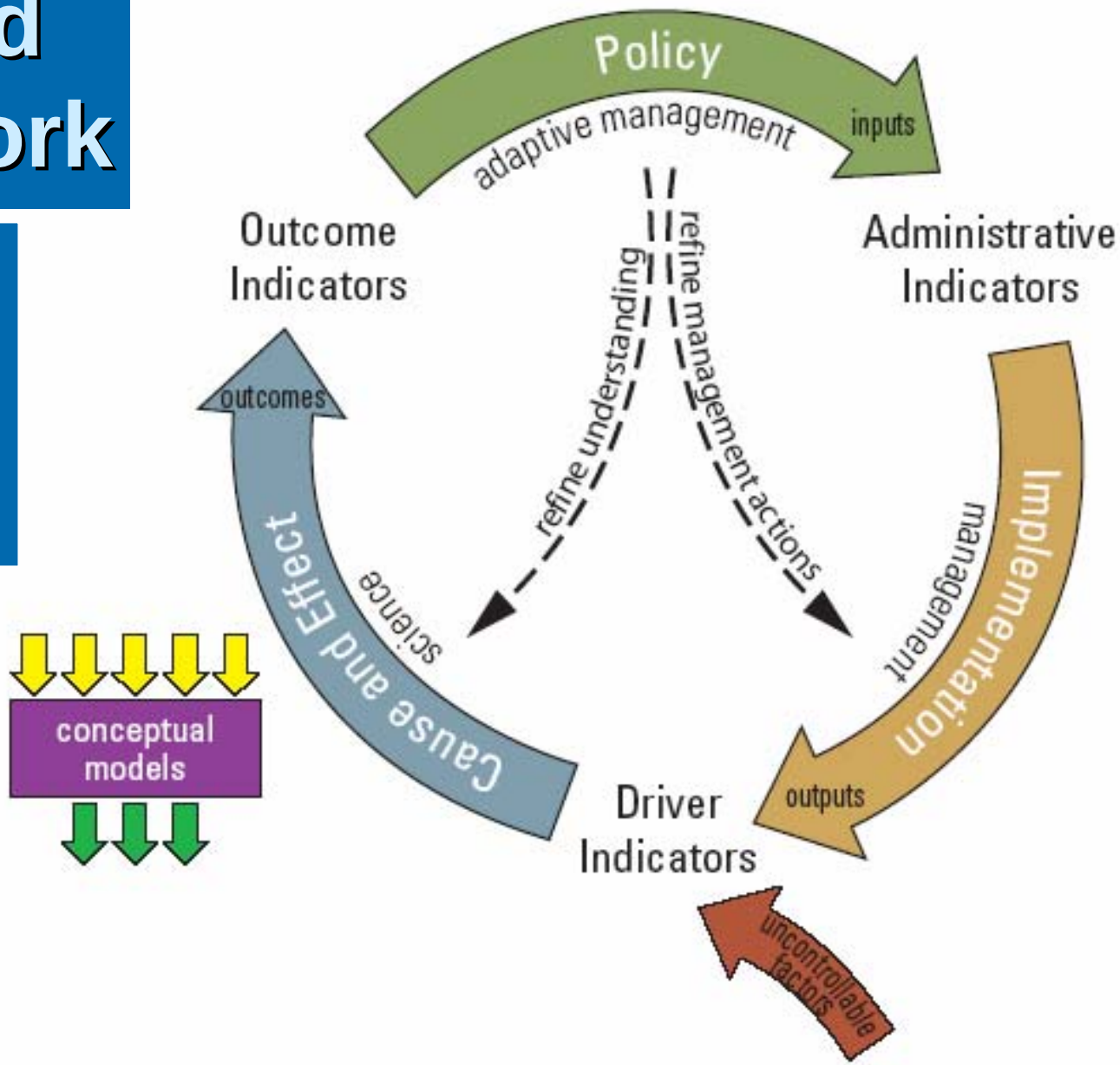
Why use indicators and performance measures?

- Assess progress towards program goals (performance assessment)
- Evaluate effectiveness of management actions
- Document changes in the system (status and trends)
- Improve our understanding of how the system works
- Inform (adaptive) management decisions

Revised Framework

Three levels of indicators:

1. Administrative
2. Drivers
3. Outcomes



3 classes of indicators

1. **Administrative indicators**

   ($, projects, programs)

2. **Driver indicators**

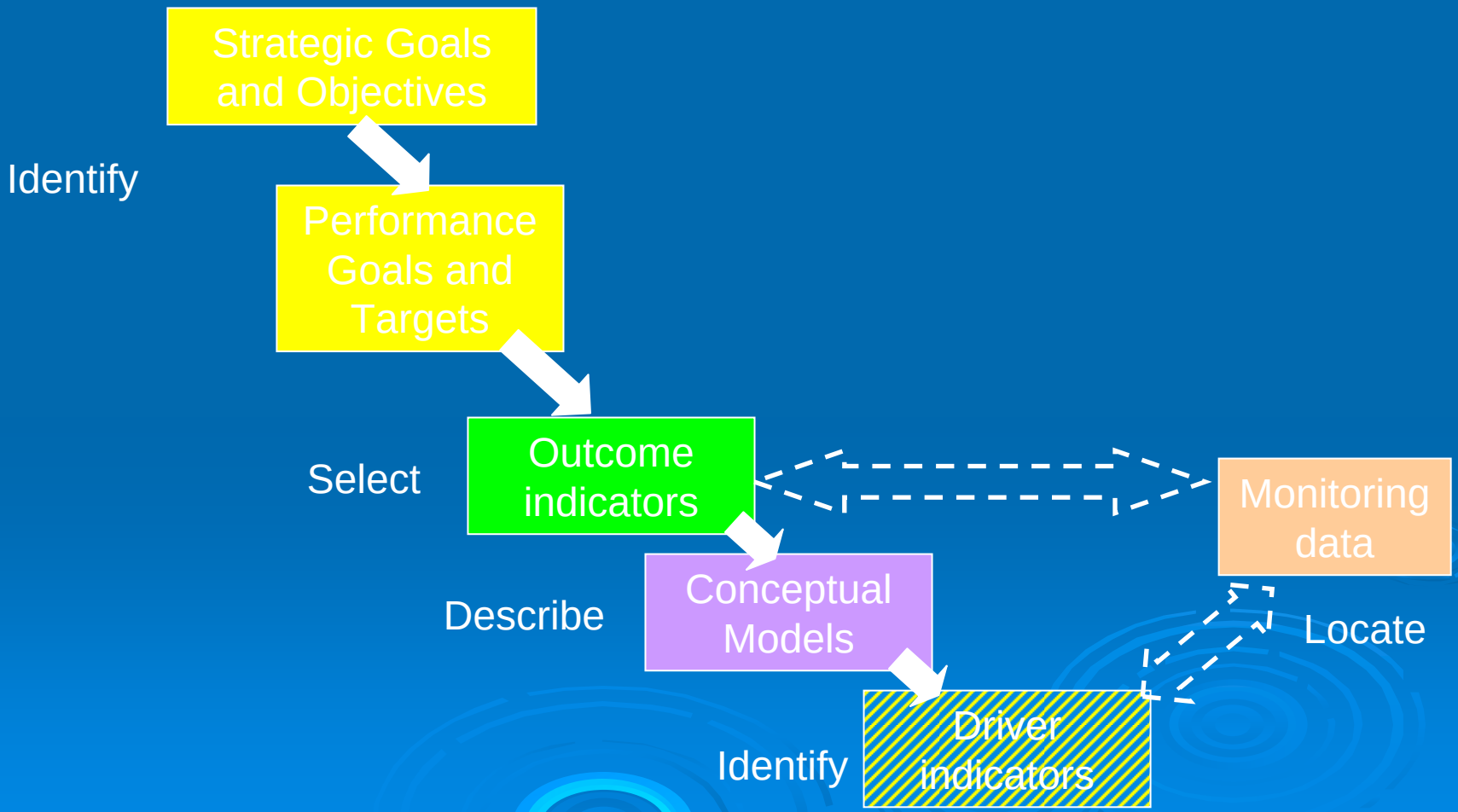
   (factors influencing outcome, including implemented management actions)

3. **Outcome indicators**

   (environmental state, DWQ, water supply reliability)

Outcome-based Approach

Four subgroups focused on 4 CALFED Objectives



Conceptual models

- Be explicit as possible
- Based on current scientific knowledge
- Describe linkages between drivers and outcomes, including a discussion of importance, understanding and predictability
- Basis of discussion for expected outcomes of management actions
- Can be quantitative models

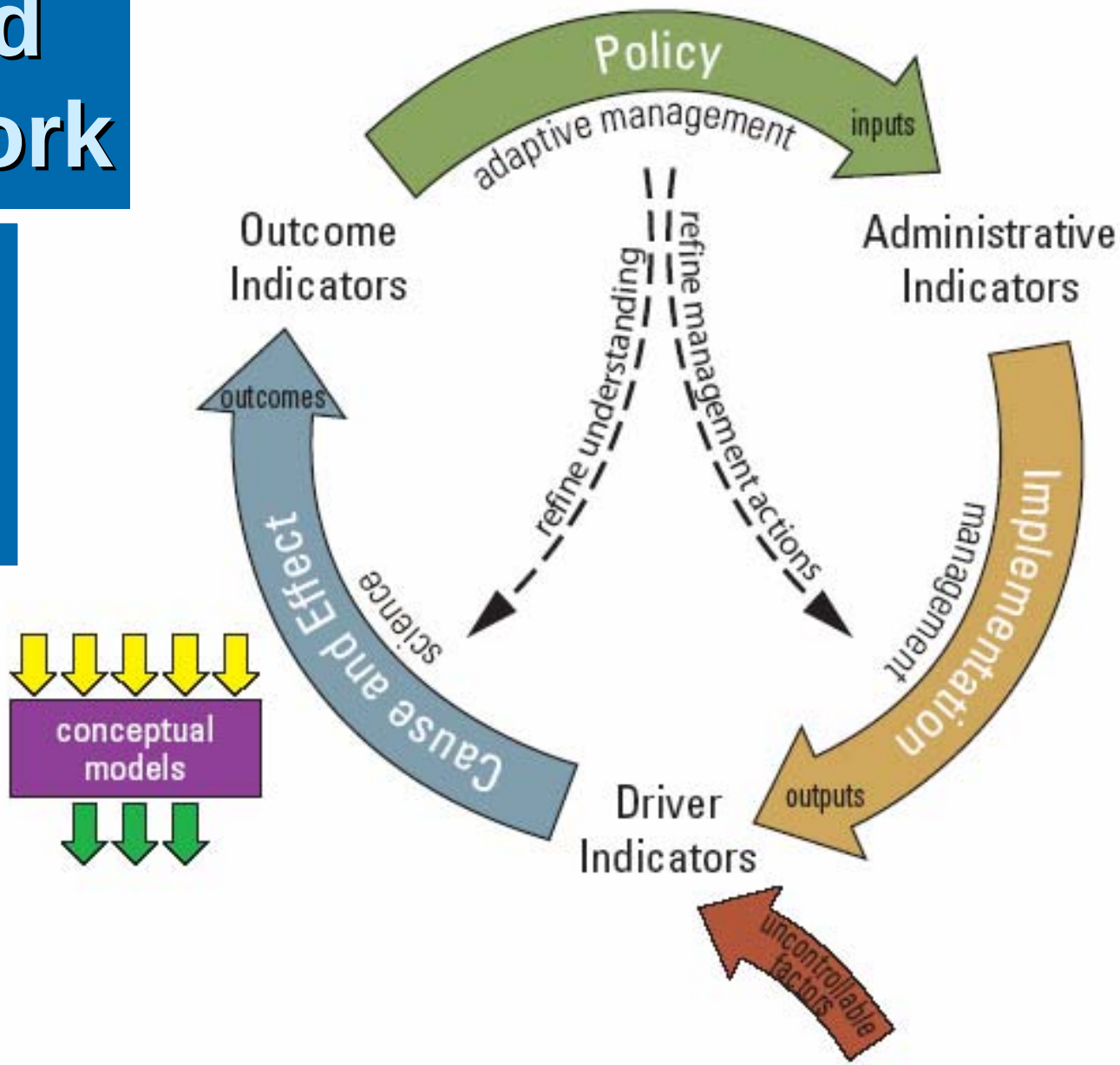
Benefits of conceptual models

- Documents rationale for decision making
- Allows multi-disciplinary review and discussion
- Reduces chances of faulty reasoning or unintended consequences
- Provides a basis for incorporating new information and continually improving knowledge of system

Revised Framework

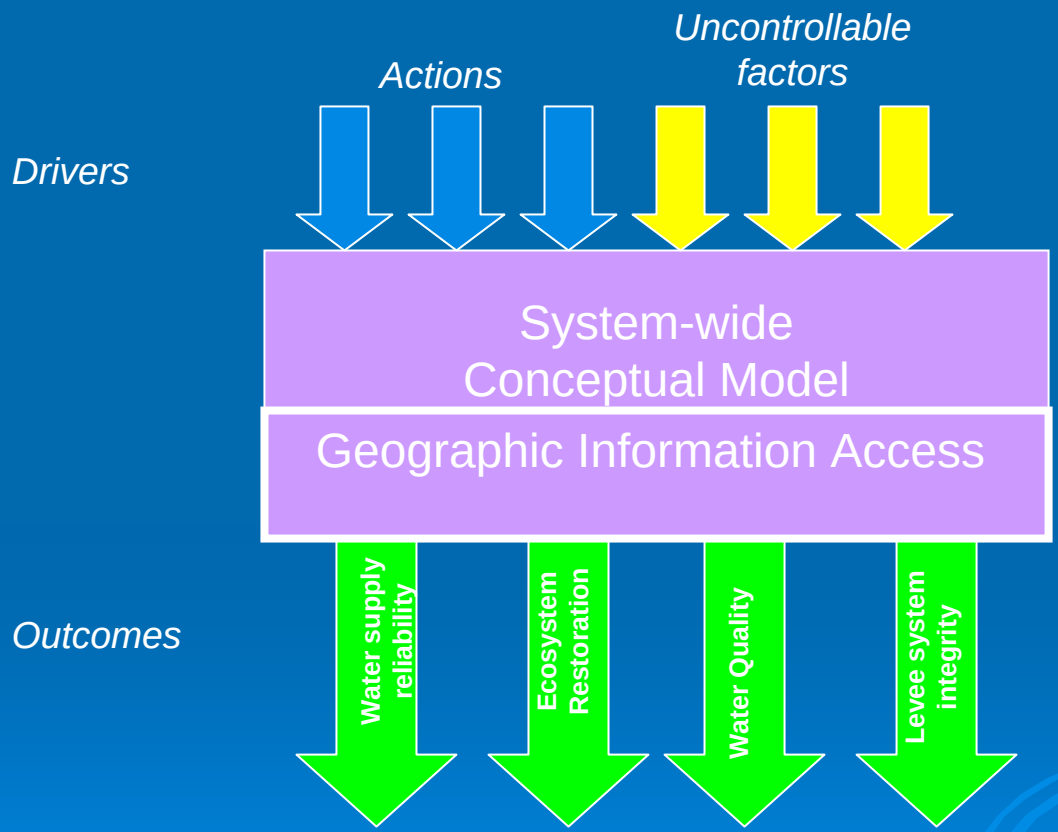
Three levels of indicators:

1. Administrative
2. Drivers
3. Outcomes

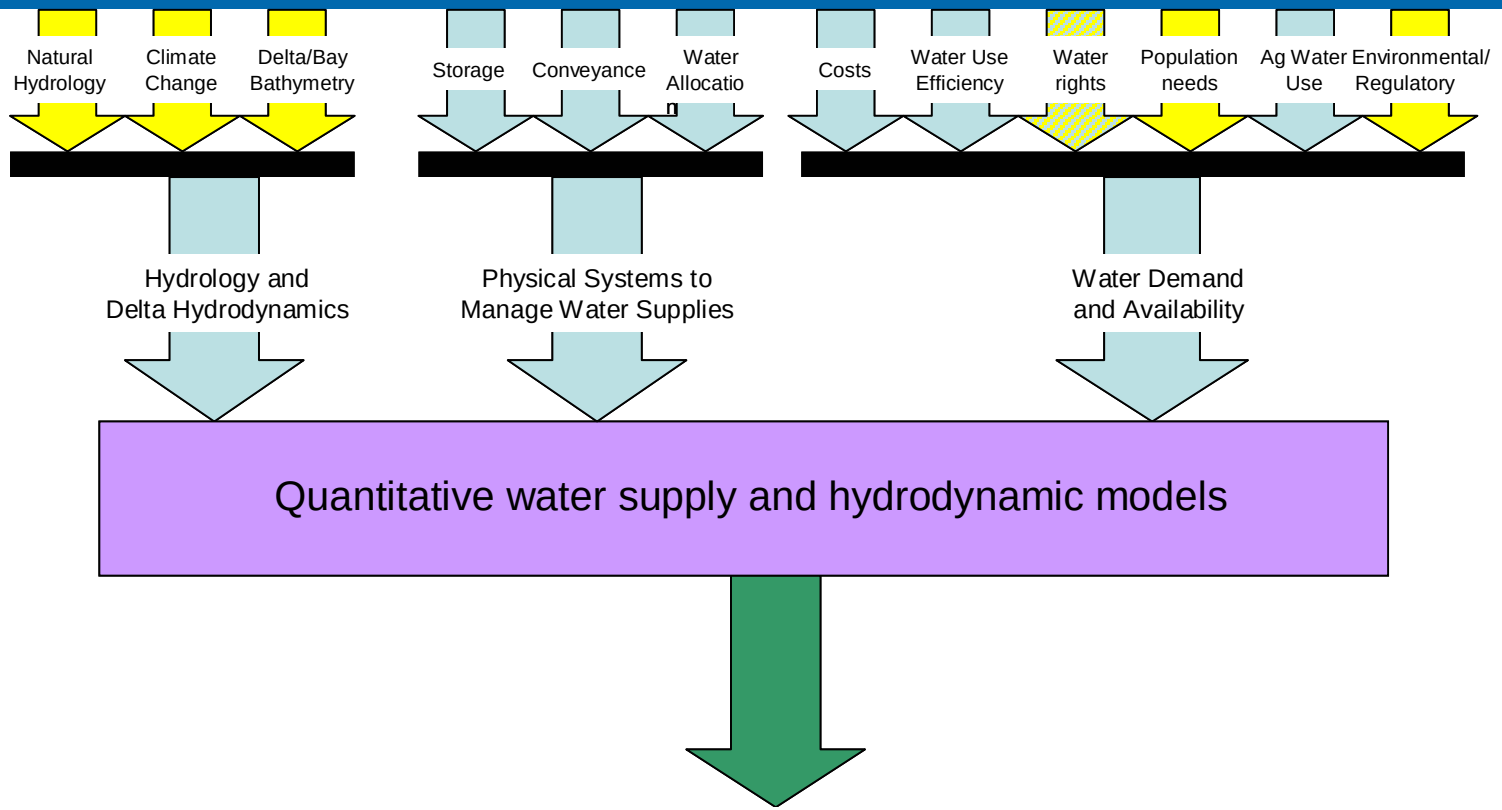


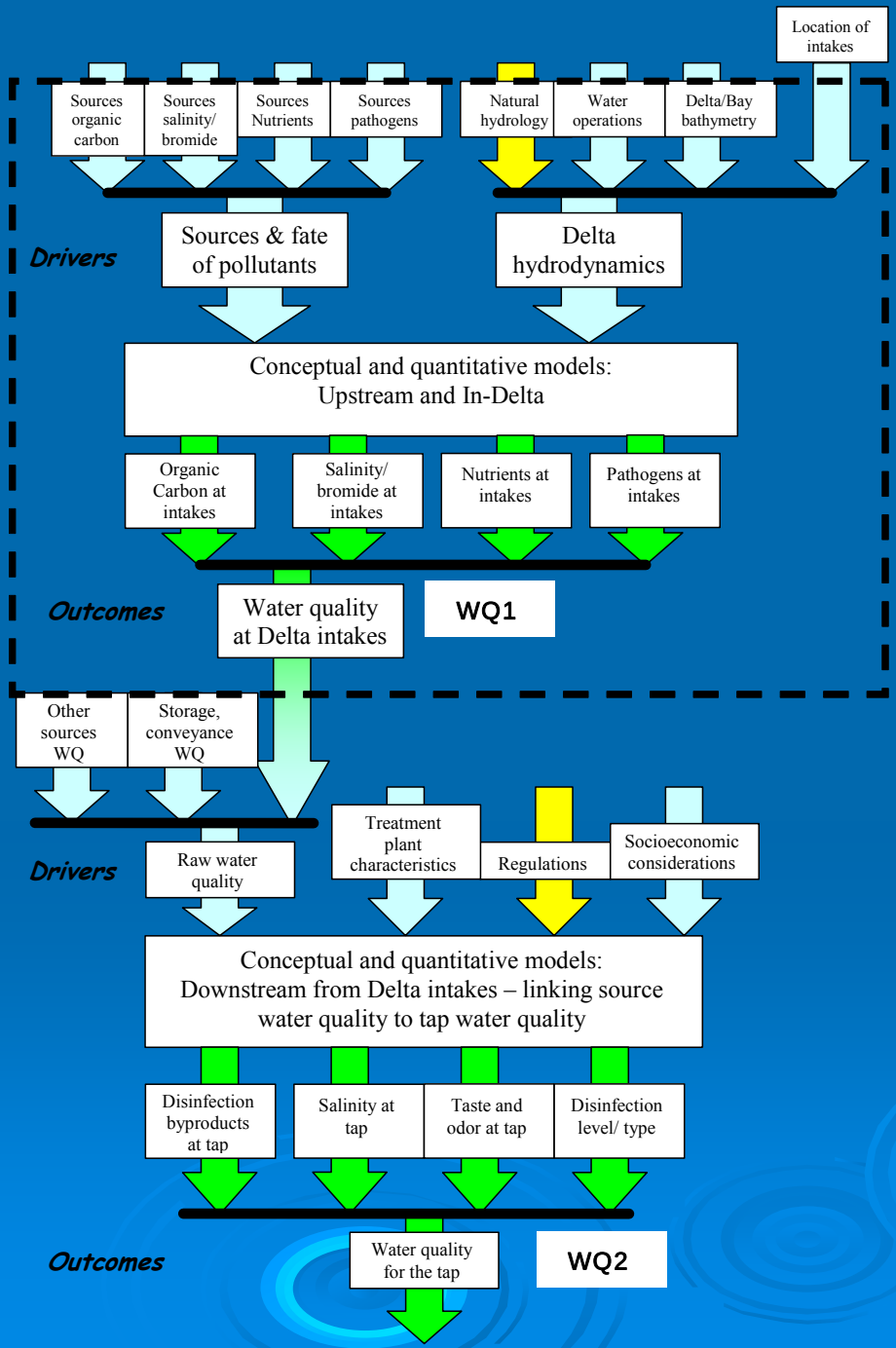
CALFED Bay Delta Program : Understanding cause and effect

Drivers and Outcome indicators



Example Conceptual Model: Water Supply Reliability



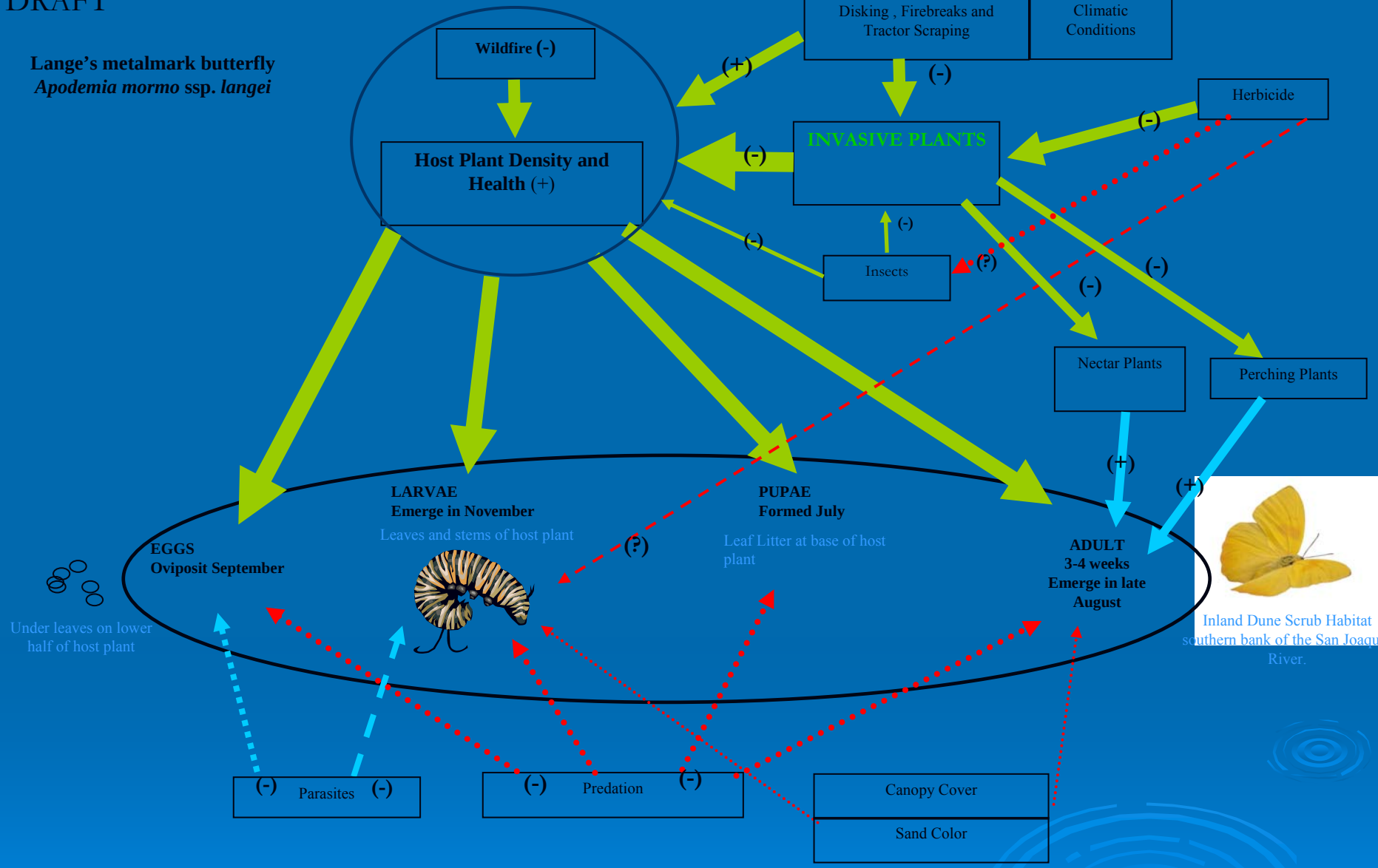

Location of intakes
Sources organic carbon
Sources salinity/ bromide
Sources Nutrients
Sources pathogens
Natural hydrology
Water operations
Delta/Bay bathymetry
Drivers
Sources & fate of pollutants
Delta hydrodynamics
Conceptual and quantitative models: Upstream and In-Delta
Organic Carbon at intakes
Salinity/ bromide at intakes
Nutrients at intakes
Pathogens at intakes
Outcomes
Water quality at Delta intakes
WQ1
Other sources WQ
Storage, conveyance WQ
Drivers
Raw water quality
Treatment plant characteristics
Regulations
Socioeconomic considerations
Conceptual and quantitative models: Downstream from Delta intakes – linking source water quality to tap water quality
Disinfection byproducts at tap
Salinity at tap
Taste and odor at tap
Disinfection level/ type
Outcomes
Water quality for the tap
WQ2

DRERIP Ecosystem CMs:
DLO Approach

- **D**rivers
  - Uncontrollable factors
  - Management actions
- **L**inkages (cause & effect)
  - Nature & direction
  - Importance
  - Certainty
- **O**utcomes
  - Environment
  - Human

DRAFT

Lange's metalmark butterfly
Apodemia mormo* ssp. *langei



Importance:	Understanding:	Predictability:
High – thick line	High – green arrow	High – solid line
Med – medium line	Med – blue arrow	Med – dashed line
Low – thin line	Low - red arrow	Low – dotted line

Blue text = Habitat preference for life stage

Note: Larvae and adult icons in graphic do not accurately portray the true appearance of the metalmark butterfly

Performance Measures Workshop

Tuesday, October 23, 2007

Elizabeth Soderstrom

CALFED Performance Measures: A Phased Approach

CALFED Performance Measures: Phase 1

- Development of Framework
- Formation of Subcommittees and Subgroups
- Phase I Report: Initial Set of PM & Implementation Plan
- Retrospective Analysis

Phase 2

- Administrative and Output PM
- Outcome PM
  - Data Analysis
  - Targets
  - Conceptual Models
- Reporting
- Integration

Phase 2

Workplan Overview

Phase 2 Work Task

1. Initiate and Plan

1.1 Finalize and Publish Phase 1 Report - V5
1.2 Identify Key Initial Performance Measures
1.3 Develop Plan and Data Collection Templates (Profile)
1.4 Conduct Performance Measures Workshop/Rally
1.5 Develop Outline of Phase 2 Report

2. Execute (12 parallel tracks)

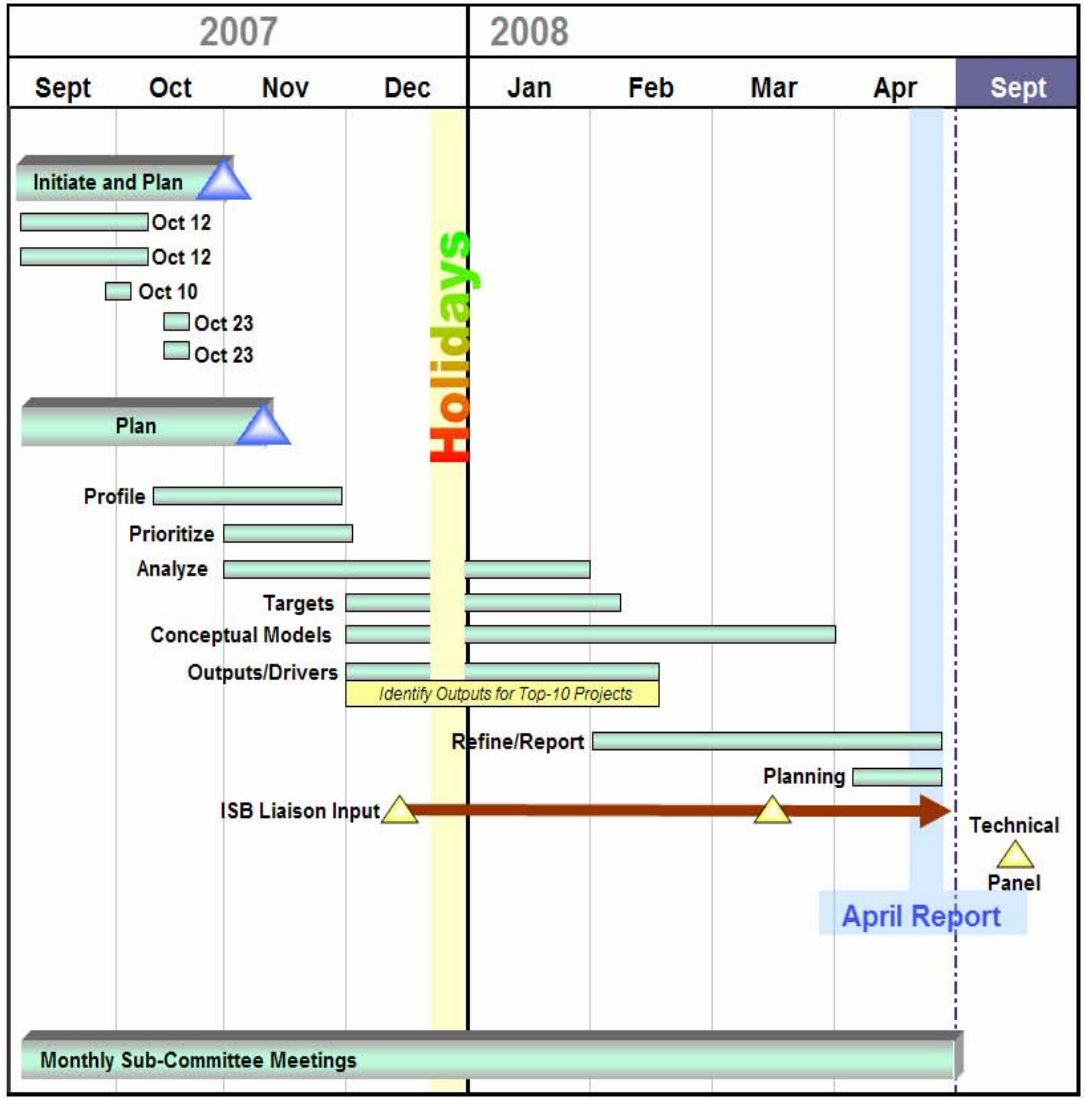
2.1 Performance Measure 1

1. Document Measure 'Profile'
2. Evaluate 'Profiles' and Prioritize
3. Collect and Analyze Data
4. Finalize Targets
5. Finalize Conceptual Models
6. Finalize Outputs/Drivers
   including select project-level outputs
7. Refine Data and Develop Draft Report
8. Future Planning (adaptive management phase)
9. ISB Liaison Input
10. Technical Panel

2.2 Performance Measure 2

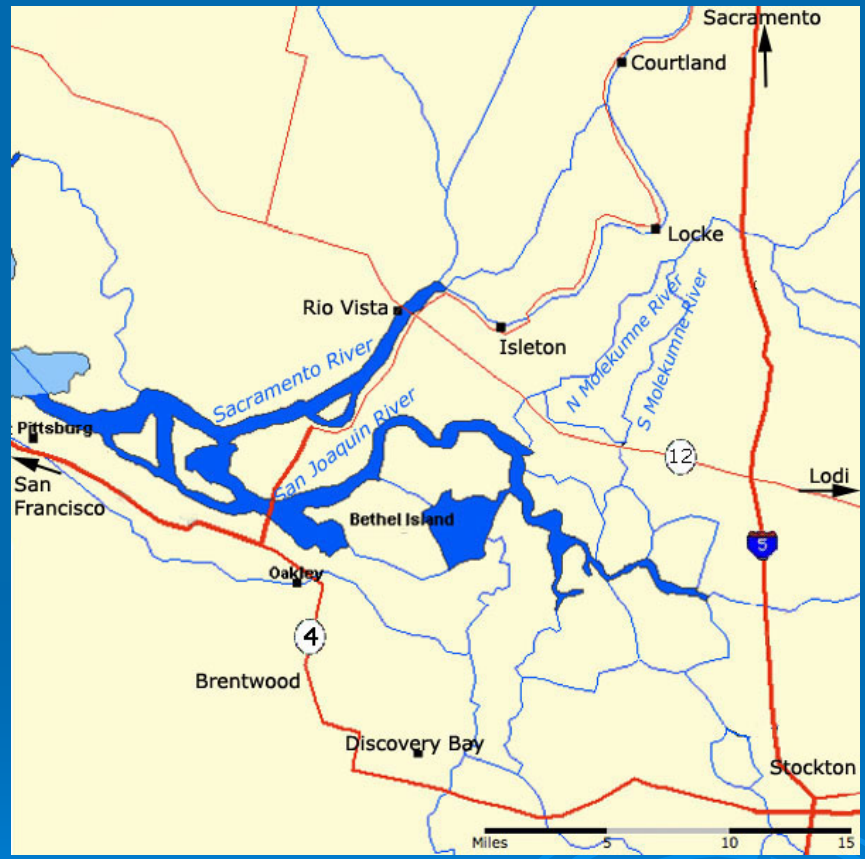
Continues . . .

3. Manage



Other Points

- Agency-led Effort
- Involvement of ISB
- From Phases to Adaptive Management



Other Thoughts

“An acre of performance is worth a whole world of promise.”
- William Dean Howells

“The only man I know who behaves sensibly is my tailor; he takes my measurements anew each time he sees me. The rest go on with their old measurements and expect me to fit them.”
- George Bernard Shaw

Agency Performance Measures Committee

Performance Measures Subgroups Presentations

Water Quality, ERP, Water Supply Reliability, Levees

Water Quality

Water Quality

Approach

- Performance measures selected:
  - based on CALFED ROD
  - represent both drinking and ecosystem water quality
  - availability of data and existing relevant analyses

Water Quality

Performance Measures

Performance Measure	*Target*	*Rationale*
➢ Annual average organic carbon & bromide at intakes	➢ 5.0 ug/L bromide (salinity measured as interim metric) ➢ 3.0 mg/L total organic carbon	➢ Indicators of DBP formation ➢ Monitored frequently in Delta and upstream watersheds, at intakes, and water treatment plants
➢ Public health protection equivalent to meeting ROD targets for bromide & TOC (a.k.a. ELPH)	➢ Under development	➢ Backstop to organic carbon and bromide targets, which may not be achievable in the Delta
➢ Toxicity to aquatic test organisms	➢ No toxicity from controllable sources	➢ Direct measure of aquatic life impacts

Water Quality

Performance Measures

Performance Measure	*Target*	*Rationale*
➢ Number of toxicity observations for which the cause and source is identified	➢ All causes and sources of toxicity of high magnitude, duration, and frequency are identified	➢ Based on need to improve and augment the suite of tools for investigating causes and sources of toxicity
➢ Methylmercury concentrations in water	➢ 0.06 ng/L (draft from Regional Water Board's TMDL)	➢ Links management action to beneficial use ➢ Measures short time-scales ➢ Needed to identify point and non-point sources and loads ➢ Needed to measure efficacy of management practices
➢ Methylmercury concentrations in tissue	➢ 0.03 mg/kg MeHg in 50 mm length fish ➢ 0.05 mg/kg MeHg in 50-150 mm length fish	➢ Represents mercury in food items ➢ Integrates factors affecting MeHg over time and space ➢ Needed to evaluate cumulative effects of management actions

Water Quality

Performance Measures

Performance Measure	*Target*	*Rationale*
➢ Methylmercury in piscivorous fish	➢ 0.24 mg/kg mercury in TL4 fish ➢ 0.08 mg/kg mercury in TL3 fish ➢ 0.2 mg/kg in SF Bay fish consumed by humans	➢ Represents risk to humans consuming Hg in fish ➢Integrates factors effecting MeHg in large fish over time ➢ Evaluates cumulative effects of management actions to reduce exposure ➢ Evaluates risk to wildlife
➢ Mercury exposure of individuals that consume Bay-Delta fish	➢ Safe eating guidelines are established ➢All individuals that consume Bay-Delta fish are aware of the health risks and benefits of eating Bay-Delta fish ➢ Human exposure to mercury is at safe levels	➢ Exposure measures & targets needed because reductions in tissue and water concentrations are estimated to take decades

Ecosystem Restoration

Ecosystem Restoration

Approach

Performance measures correspond to goals and objectives of ERP Strategic Plan, pursuant to CALFED ROD

- **At risk species**
- **Ecological processes**
- **Habitats**
- **Non-native invasive species**
- **Water and sediment quality**
- **Harvested species**

Ecosystem Restoration

Approach (Cont.)

Short-term:

- **Define initial broad-based PMs using existing information**
- **Refine selected PMs for example key species**
- **Identify data gaps and needs for further program direction**

Ecosystem Restoration

Approach (Cont.)

Long-term:

- **Update ERP restoration priorities, opportunities, and targets based on newly emerging information**
- **Refine additional PMs for key ERP objectives**
- **Develop monitoring program to integrate with PMs**

Ecosystem Restoration

Issues

Development of Ecosystem PMs constrained by incomplete information

- **ERP Stage 1 assessment underway**
- **ERP Conservation Strategy under development**
- **Delta water conveyance planning underway**
- **Recovery Plans for federally-listed species under development**
- **Biological information emerging from POD studies**
- **Climate change projections uncertain**

Ecosystem Restoration

Performance Measures

Performance Measure	***Target***
➢Achieve recovery of CALFED “R” species	➢Minimum viable population with risk of extinction not to exceed 5% chance over 100 years (or similar criterion)
➢Contribute to recovery of CALFED “r” species	➢Positive population trend or stable numbers at predetermined benchmark
➢Conserve non-listed native species	➢Stable populations or positive population trends

Ecosystem Restoration

Performance Measures

Performance Measure	***Target***
➢Restore natural ecosystem processes	➢Based on measured values of indicators for natural processes (to be determined)
➢Sustain populations of non-listed harvested species	➢Increase numbers from established baseline or maintain stable populations
➢Protect ecosystem integrity measured in broad-based indicators of ecosystem "health"	➢Diversity indices, community metrics, or other measures (e.g., Shannon's H or Simpson's D and E) at values to be defined

Ecosystem Restoration

Performance Measures

Performance Measure	***Target***
➢Performance of programs for prevention, control, and eradication of non-native invasive species (e.g., DFG Plan 2006)	➢No new colonization and no net increase in range or dominance of extant species
➢Reduce or eliminate impacts to contaminant exposed populations and community components upon which these species depend	➢Based on reduction or remediation of known contaminants to lesser of: 1) lower 95% confidence limit of EC_{10} (for non-lethal endpoints) or 2) $\leq LC_{01}$ for the 95% most sensitive species (where mortality is the endpoint of concern)

Ecosystem Restoration

Performance Measures: Recovery of "R" Species

Performance Measure	*Target*	*Rationale*
➢Achieve recovery of Delta smelt	➢Minimum viable population (MVP); e.g., risk of extinction <5% over 100 years -OR- ➢Fall midwater trawl index of value to be determined	➢Selected for regulatory interest (listed species for DFG, NMFS, and FWS), POD species, recovery plans in progress, monitoring data available, key species in Delta restoration and water management planning ➢Conceptual models complete or nearing completion ➢Must be integrated with recovery plan development and planning for Delta water conveyance
➢Achieve recovery of spring-run Chinook salmon	➢Viable salmonid population (VSP). Criteria include abundance, diversity, productivity, and spatial structure.	
➢Achieve recovery of Lange's metalmark butterfly	➢Minimum viable population (MVP); e.g., risk of extinction <5% over 100 years	

Water Supply Reliability

Water Supply Reliability

General Approach

- Focused on measures that were immediately implementable
- Limited to project operation measures such as delivery reliability and meeting standards and requirements
- Did not address beneficial uses of supplies such as effects on aquatic habitat

General Approach (continued)

Kept the performance measures practical and meaningful

Water Supply Reliability

Performance Measures

Performance Measure	*Target*	*Rationale*
Annual number of incidences when project-related Delta standards and requirements are not met.	Zero incidences of not meeting Delta standards and requirements	Measures whether projects provided water supply in sufficient quantity and timing to meet standards and requirements for the protection of water quality and the ecosystem.
Acre-feet of unexpected reductions in SWP water supplies to protect water quality or the ecosystem in given year	Zero unexpected reductions in SWP water supplies for a given year	Measures degree of confidence that a scheduled quantity of water will be delivered as planned for a given year
Acre-feet of SWP water supplies in a water year with a description of the conditions during the water year	Actual annual deliveries within one standard deviation of the long term statistical mean for a given water year type	Measures the level of certainty of Delta water deliveries relative to an estimated long-term delivery capability

Levee System Integrity

Levee System Integrity

Goal:

- **To reduce the risk to land use and associated economic activities, water supply, infrastructure, and the ecosystem from catastrophic breaching of Delta levees.**

Levee System Integrity

Approach:

- **Funding for maintenance of Delta levees.**
- **Facilitate and support studies in the Delta to ensure structural integrity of the levees.**
- **Work with stake holders and the Legislatures in support of Delta levees programs.**
- **Integrate habitat enhancement within the Program.**

Levee System Integrity

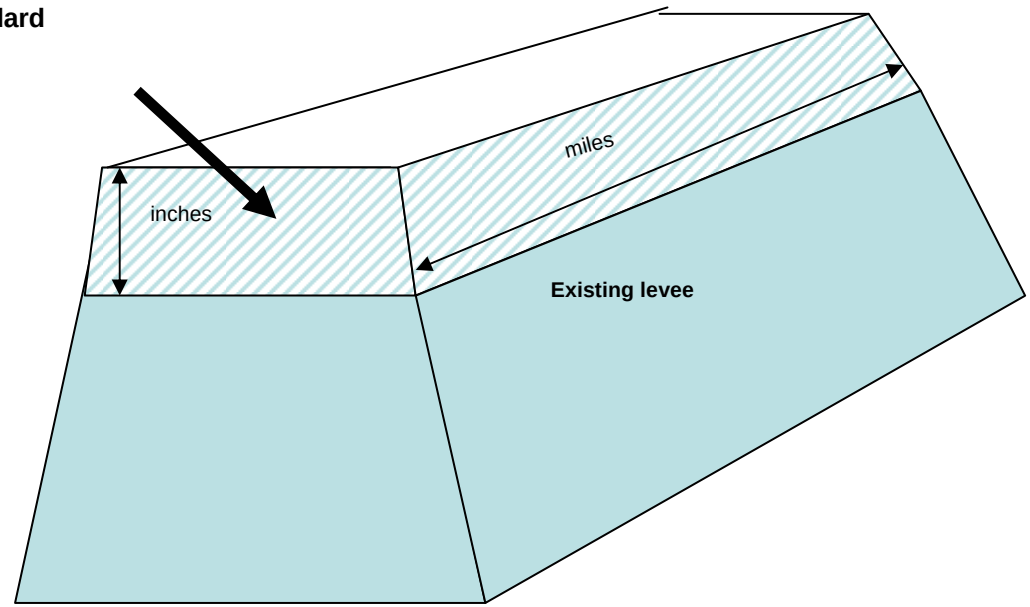
Performance Measures

(Note: Key performance measures are highlighted in red)

Performance Measure	***Target***	***Rationale***
➢KIM (Kilo-Inch-Mile): An overall measure of net work to achieve PL 84-99 standard.	➢KIM=0 (A Zero KIM Target represents that there is no additional work to be done to meet the standard).	➢Some recent levee crest elevations exist from previous works. This data can be used to develop the KIM and RKIM on some islands. DWR has completed the LiDAR; data will be available for the KIM and RKIM baseline.
➢RKIM (Risk-adjusted-Kilo-Inch-Mile): A measure of risk associated with inadequate and sub-standard levee maintenance.	➢RKIM=0 (A Zero RKIM Target represents no risk).	➢DWR has completed the LiDAR; data will be available for the KIM and RKIM baseline. Levee crest elevation updates are few and far between. We expect to perform LiDAR survey every 5 – 7 years.
➢Number of levee miles or islands enhanced above PL84-99 flood protection standard.	➢400 miles, of total 500 miles of project levees, at or above the PL 84-99 standards. Goal is to increase bring all levees to the same standard.	➢LiDAR survey planned for every 3-5 years, levee cross-sections, annual levee maintenance inspections, and land surveys are essential. DWR completed LiDAR and provides funding for maintenace inspection.

Levee System Integrity

KIMs needed to meet standard



KIM = kilo-inch miles

Levee System Integrity

Performance Measures

(Note: please highlight key performance measures in red)

Performance Measure	*Target*	*Rationale*
➢Number of miles with electro-magnetic conductance anomalies quantified.	➢We offer reimbursements to the districts participating in the Electromagnetic Survey program. To-date, m*ore than 25 LMA have chosen to take advantage of this program and about 400 miles of levees have been quantified. The target is 700 miles by end of FY 2007-08.*	➢Up to 50% of the Delta expected to be surveyed using the most accurate techniques. Follow-up work is expected to be done to investigate the anomalies detected in Reclamation Districts that participated in the locating phase of the survey.
➢Acreage of islands/tracts with subsidence control measures in areas that affect levee stability.	➢Subsidence control is continuous work in the Delta. *Some subsidence reversal efforts are being planned for Sherman & Twitchell islands, which totals about 700 acres.*	➢Project descriptions have been formulated and contain information regarding acreage of land under consideration. Projects are now in the planning stages.

Levee System Integrity

Performance Measures

(Note: please highlight key performance measures in red)

Performance Measure	***Target***	***Rationale***
➢Improvements to emergency response.	➢*The Flood Operations Center is preparing an Emergency Operations Plan for the Delta. They are considering single and multiple breaches and formulating a flood fighting plan. We are also providing SEMS training for staff*. Additionally, staff has been able to form a regional emergency response committee with county and city officials being active participants.	➢There is a need for additional hydraulic and forecast modeling to better understand the potential consequences and complete a preparedness plan. River and weather forecast modeling is needed to understand the needs for emergency response. DWR Hydrology Branch is performing hydraulic modeling for various scenarios to understand the needs for emergency response.

Beyond CMARP

Dr. Sam Luoma

Build from Experience

- ***Water Framework Directive***: Member States shall ensure the establishment of programmes for the monitoring of water status in order to establish **a coherent and comprehensive overview of water status** within **each river basin district:**

- Goals=Status: systematic, comparable, coherent, and comprehensive
  - Rank water basins: unimpaired, moderately impaired, impaired…determines level of attention by govt.
- Scale= River basin

National Water-Quality Assessment Program (NAWQA)

Design challenges in monitoring & assessment

Samuel N. Luoma[1], Donna Myers[2]

[1]USGS, Menlo Park, CA & The Natural History Museum London; [2]USGS Reston VA

Circumstances: Bay-Delta

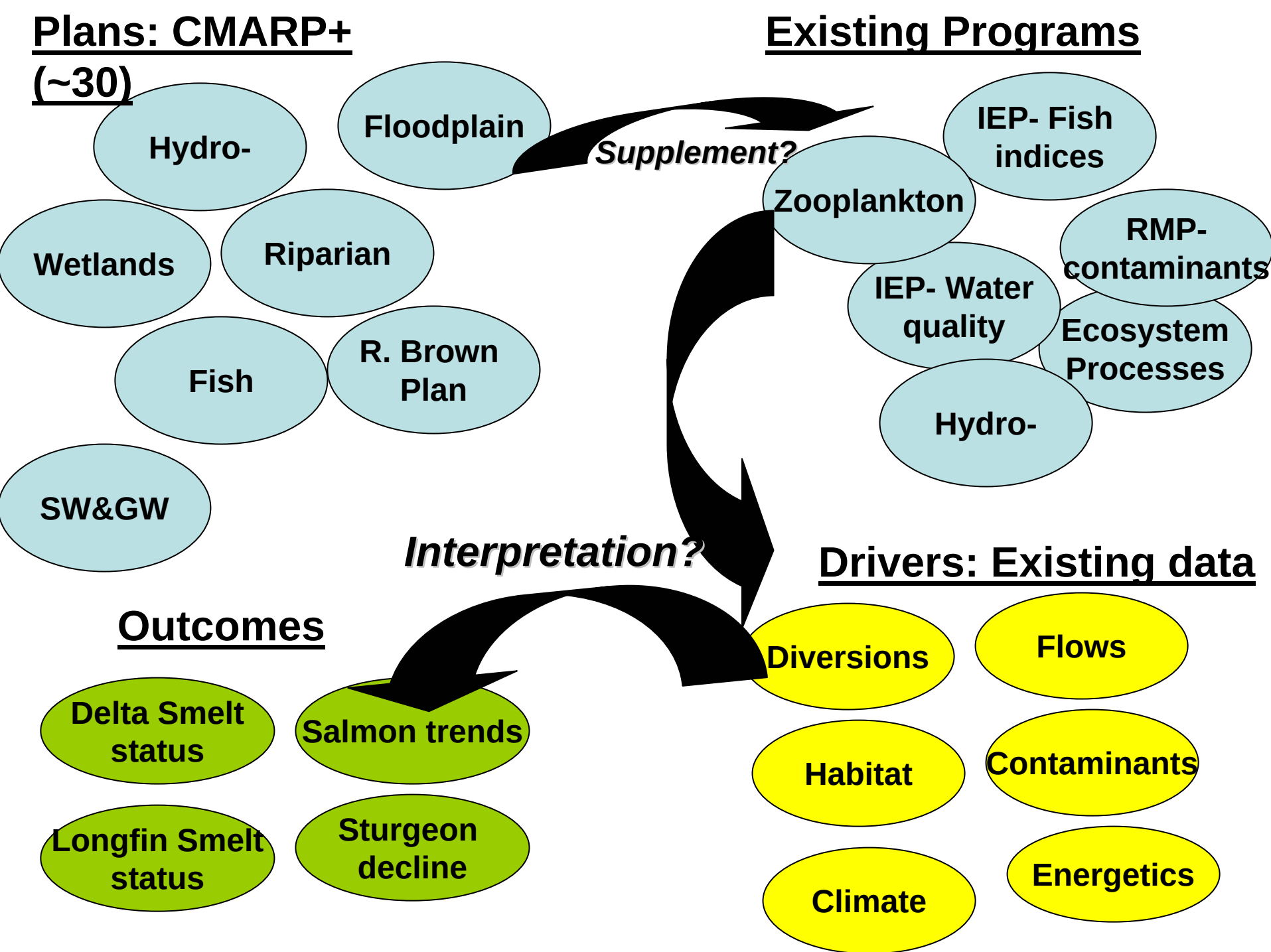
- **Watershed system (Sierra to Pacific Ocean), with linked streams, rivers, Delta and estuary.**
- **Multiple Stressors: Flows, contaminants, diversions, temperature, climate change, habitat disruption, modified water quality, etc.**
- **Multiple species of interest: smelt, salmon, sturgeon, native fishes in general and that is just fish.**
- **Multiple ecosystems of interest: lotic, wetlands, shallow water, delta lakes, estuarine benthos and water column.**

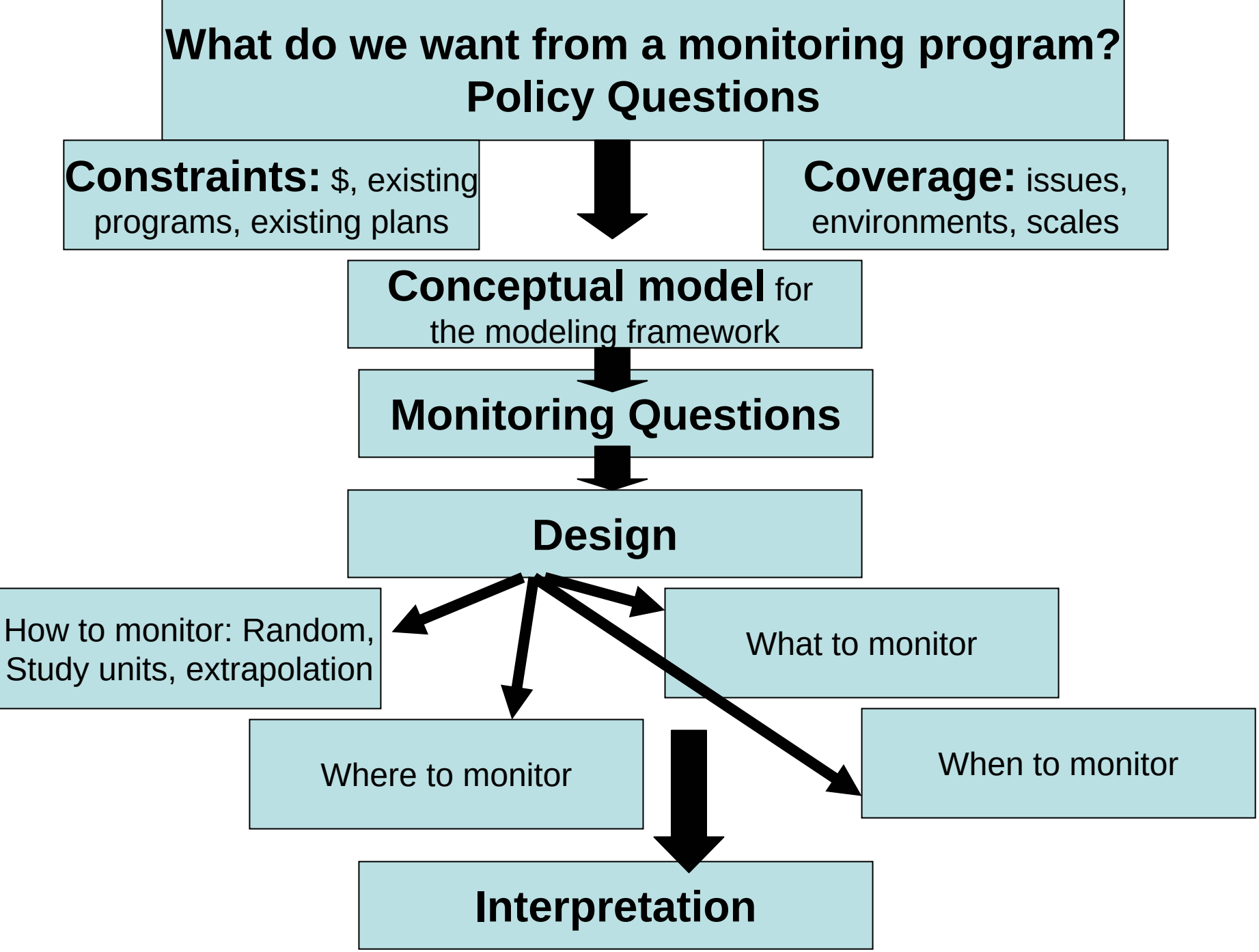
Circumstances: Bay-Delta

- **Existing monitoring systems cover individual aspects of the overall challenge**
  - **IEP, RMP, smaller efforts: from large and integrated to disparate and unconnected.**
  - **Universal shortage of integrated interpretation.**
- **Monitoring Plans: CMARP, R. Brown, TAMP**
  - **Comprehensive lists of monitoring needs for different aspects and different problems. No unified program.**
- **Multiple political goals: water supply, restoration, water quality, levees.**

Circumstances: Bay-Delta

- Multiple types of systems: Tributaries, rivers, groundwater, Delta, estuary
  - Existing data is not coherent to system
  - Need: comparability among different systems or status of each type of system?
  - Usefulness at different scales?
    - Restoration project (has project improved conditions?), river basin (status of major populations; habitat, flows, influence of restoration), inputs to Delta as a whole (flows, migrant species, contaminants, carbon), Delta itself (status and internal stressors), input to estuary (flows, contaminants), Bay, watershed (anadromous species, overall status of groundwater or storage or freshwater water reliability).


Plans: CMARP+ (~30)
Hydro-
Floodplain
Wetlands
Riparian
Fish
R. Brown Plan
SW&GW
Supplement?
Existing Programs
IEP- Fish indices
Zooplankton
RMP- contaminants
IEP- Water quality
Ecosystem Processes
Hydro-
Interpretation?
Drivers: Existing data
Diversions
Flows
Habitat
Contaminants
Climate
Energetics
Outcomes
Delta Smelt status
Salmon trends
Longfin Smelt status
Sturgeon decline


What do we want from a monitoring program?
Policy Questions
Constraints: $, existing programs, existing plans
Coverage: issues, environments, scales
Conceptual model for the modeling framework
Monitoring Questions
Design
How to monitor: Random, Study units, extrapolation
What to monitor
Where to monitor
When to monitor
Interpretation

Policy Questions

- **Are we achieving political goals?**
  - Status of water supply?
  - Status of restoration?
- **Are goals resulting in anticipated changes?**
  - Trends in ecological indicators?
  - Trends before and after restoration, or changes in diversions?

Policy Question: Which goals are achieving results?

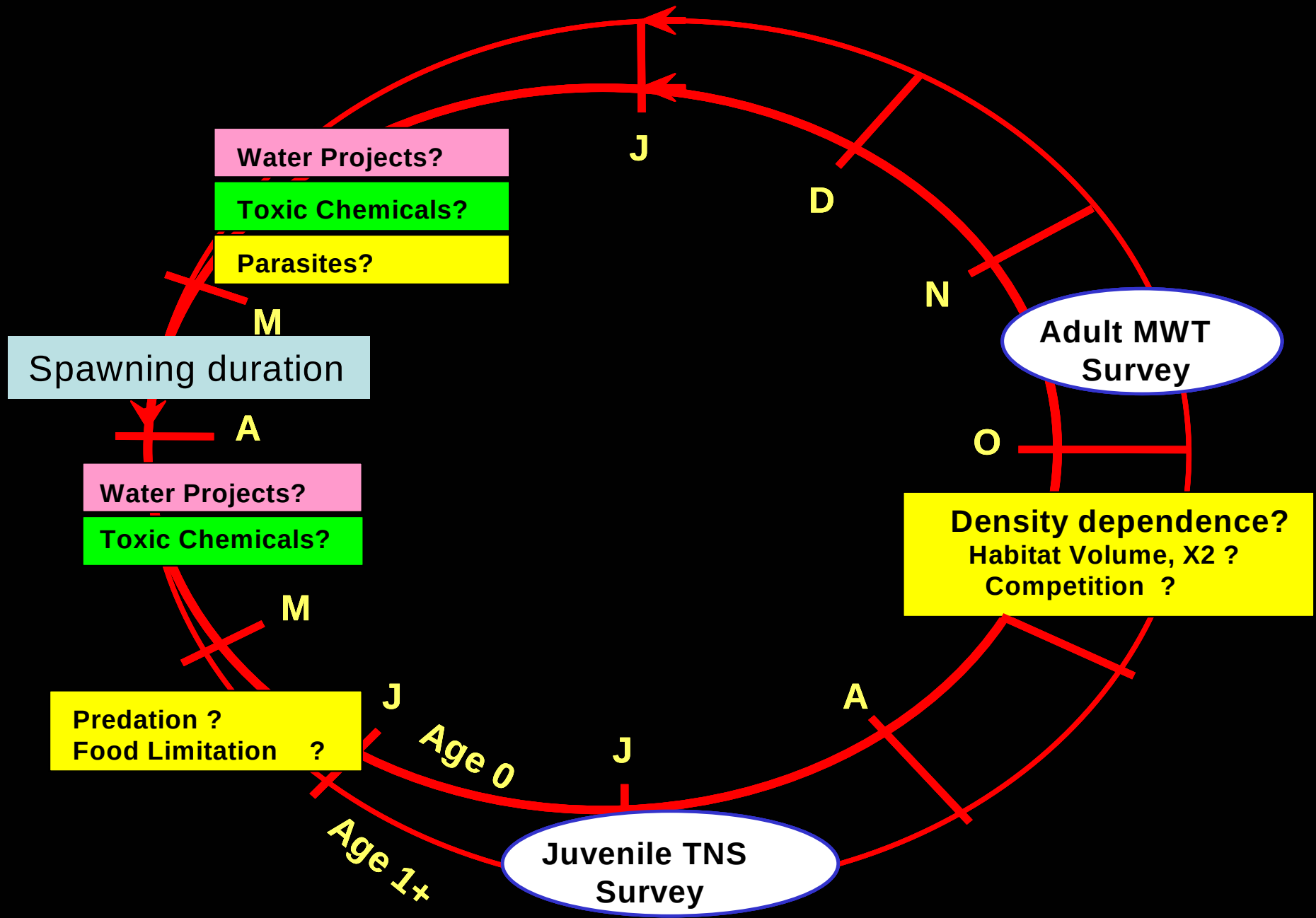
Approaches to Restoration (emphasis on rivers)

Inject sediment
Gravel Augmentation
Remove dams
Manage flows
Riparian revegetation
Riparian preservation
Innundation of riverine floodplains
Removal of exotics (Effect of exotics?)
Correct contamination sources (Role of contaminants?)
Tailwater restoration ponds with Sustainable Agriculture
Perpetuate sustainable agriculture and revegetate adjacent ecosystems

Policy Questions: Choices

- **Regulatory mandate? Where is the system out of compliance with existing laws?**
  - Flows, pesticides, metals, drinking water quality
- **Prioritize investments? Overall ecological status (rivers, water bodies/basins or estuary)?**
  - What rivers should we focus on? On focus on Delta appropriate?
- **What is status and what are trends in individual species, diversions, reliability of supply, ecological processes?**
  - fish indices, metals, endocrine disruption, impact of floods (levees)
- **Why are [subject of interest] in trouble?**

Gauntlet for Delta Smelt



Scientific Goals

- **Status** – "a coherent and comprehensive overview of water status"
  - "**Surveillance monitoring**"
- **Trends** – "the assessment of **long-term changes** in natural conditions, and… resulting from widespread anthropogenic activity."

- **Explanation** – "in order to ascertain the causes of a water body or water bodies failing to achieve the environmental objectives"
  - "**Investigative monitoring**"

Choice of overall design

- **Probabilistic design**
  - Stations chosen randomly and distributed across area of interest
  - Snapshot; Is there a problem and how big is it?
  - Compliance – what percent impaired? Simpler design
- **Targeted study units**
  - Stations targeted into pre-selected locations, which represent other locations
  - Expand area with rotational Scheme
  - Status, trends and explanation in each study unit, over time.
- **Process design**
  - Understand processes driving water quality in detail in a few places and extrapolate to elsewhere
  - Evolving design as framework shifts with new discoveries.

SELECTION CRITERIA FOR STUDY UNITS

- Coverage: 60-70% of water use and population
  - More than 50% of the land area
  - Balanced coverage in terms of
    - geographic region
    - hydrologic and climatic setting
- Complement at least selected existing programs
- Represent an array of critical issues

Choice of variables

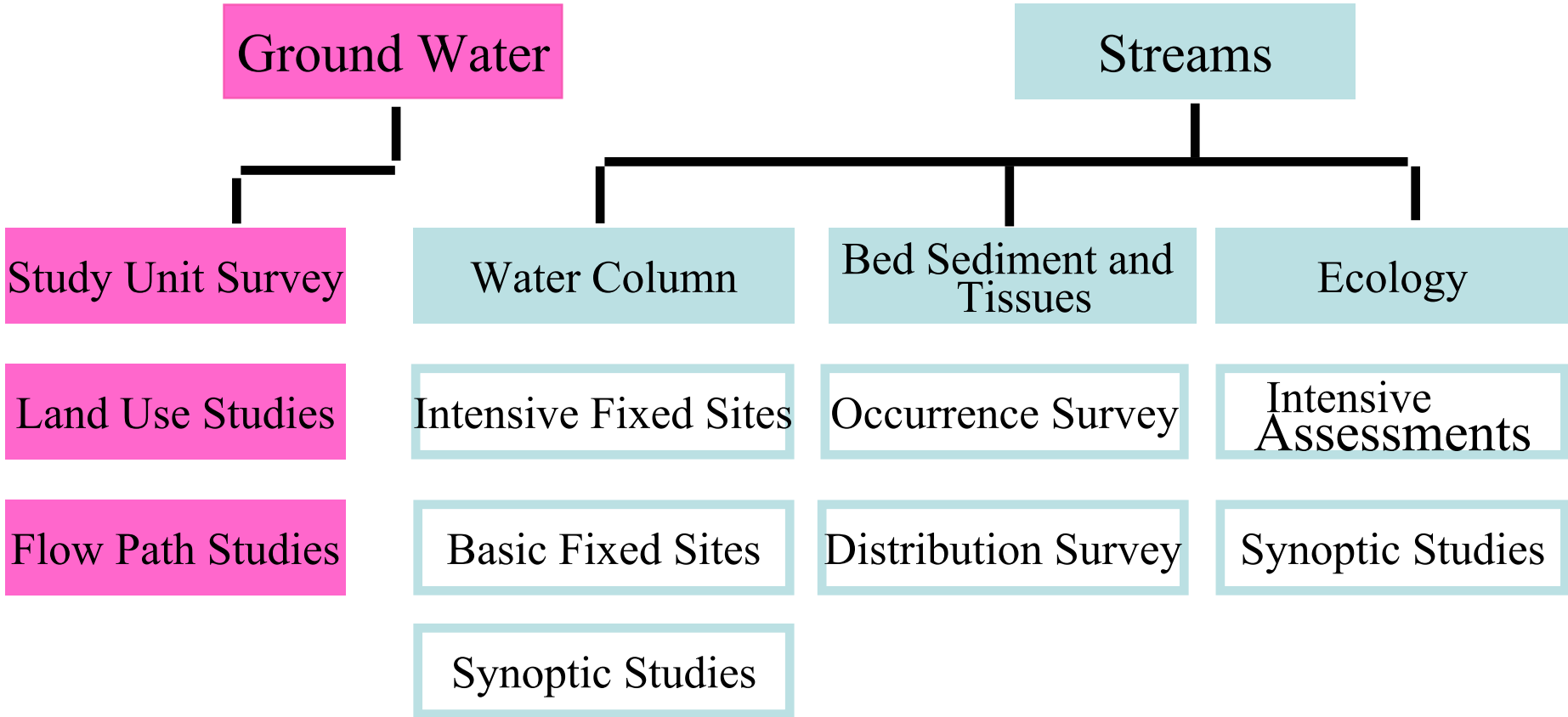
- **Physics…**the volume and level or rate of flow
- **Biol/Ecology…**to the extent relevant for ecological and
- **Chemistry…**chemical status and ecological potential,

Environmental factors & communities

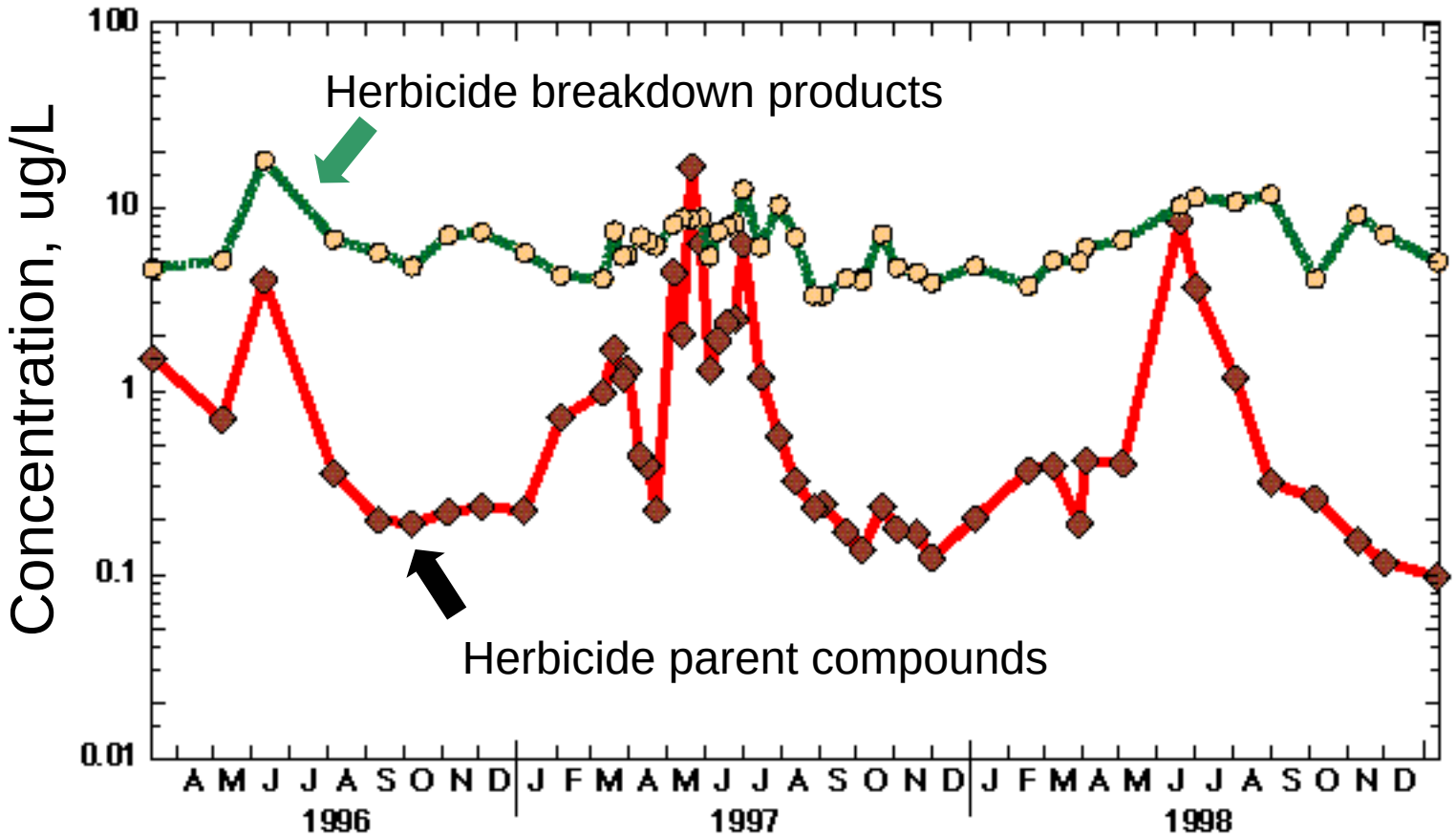
Table 4. Environmental factors that were highly related to impairment of fish, aquatic-invertebrate, and algal communities along an urban land-use gradient. Green shading indicates factors that were more favorable to healthy aquatic communities and red shading indicates factors that were less favorable. [NS, No statistically significant effect on aquatic community]

	Response of aquatic community		
Watershed characteristic	Fish	Aquatic invertebrates	Algae
Area of forest and wetlands	NS	Positive	NS
Ability to maintain base flow	NS	Positive	NS
Percentage of cobble substrate	Positive	Positive	NS
Median sulfate concentration	NS	Positive	Positive
Median total phosphorus concentration	Negative	NS	Positive
Mean annual flood	Negative	Negative	Negative
Flashiness of streamflow	Negative	NS	NS
Impervious area, road area only	Negative	Negative	Negative
Impervious area, nonroad area only	NS	Negative	NS
Population density	Negative	Negative	Negative
Total urban area in 1986	Negative	NS	NS
Urban area growth from 1986 to 1995	NS	Negative	NS
Commercial and industrial area in 1986	NS	Negative	Negative
Total point-source flow	NS	Negative	NS

OCCURRENCE AND DISTRIBUTION ASSESSMENT



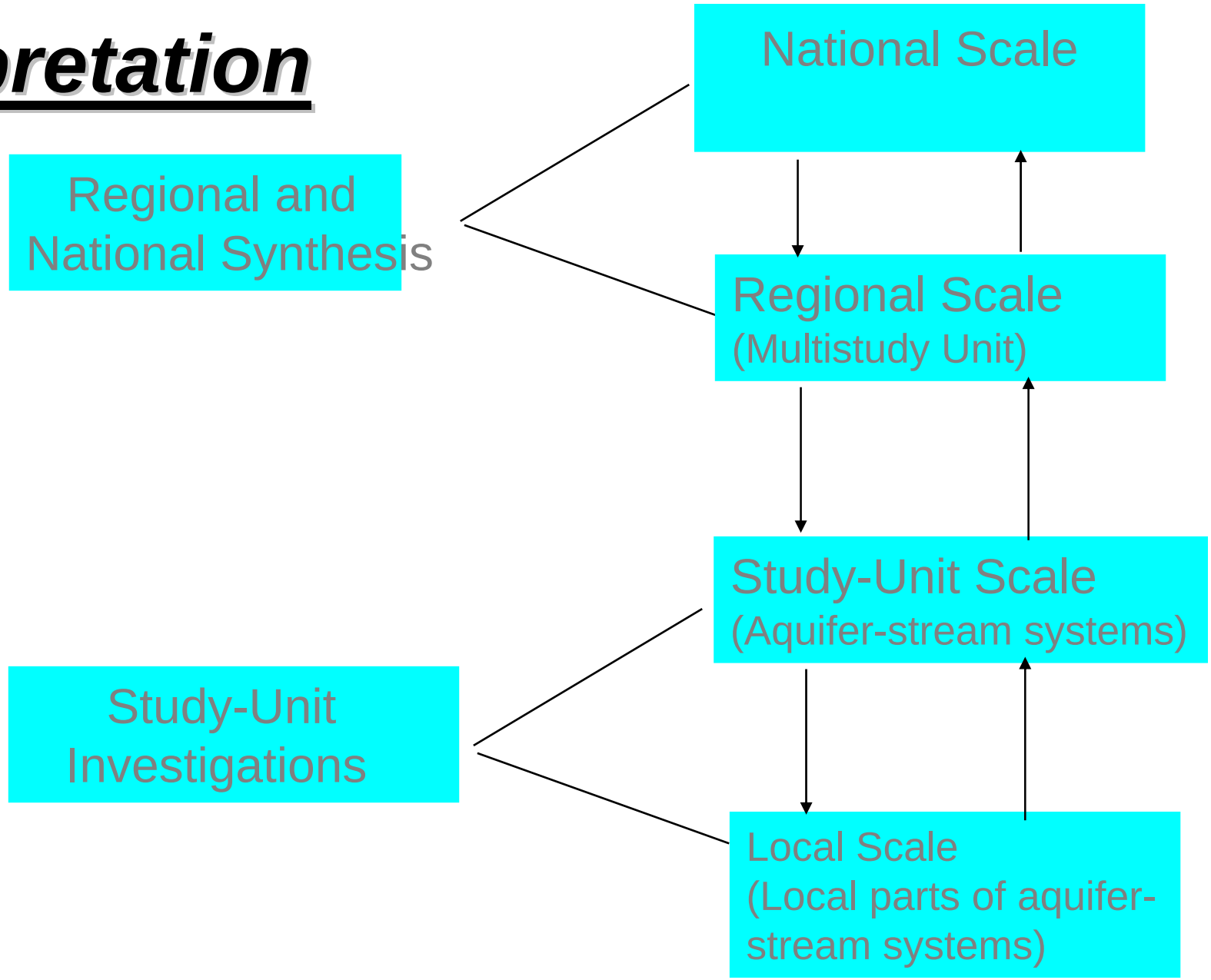
Breakdown Products Often Total 10 to 25 Times the Concentration of Parent Compounds in the Iowa River



Why Use Sediment Cores to Quantify Trends?

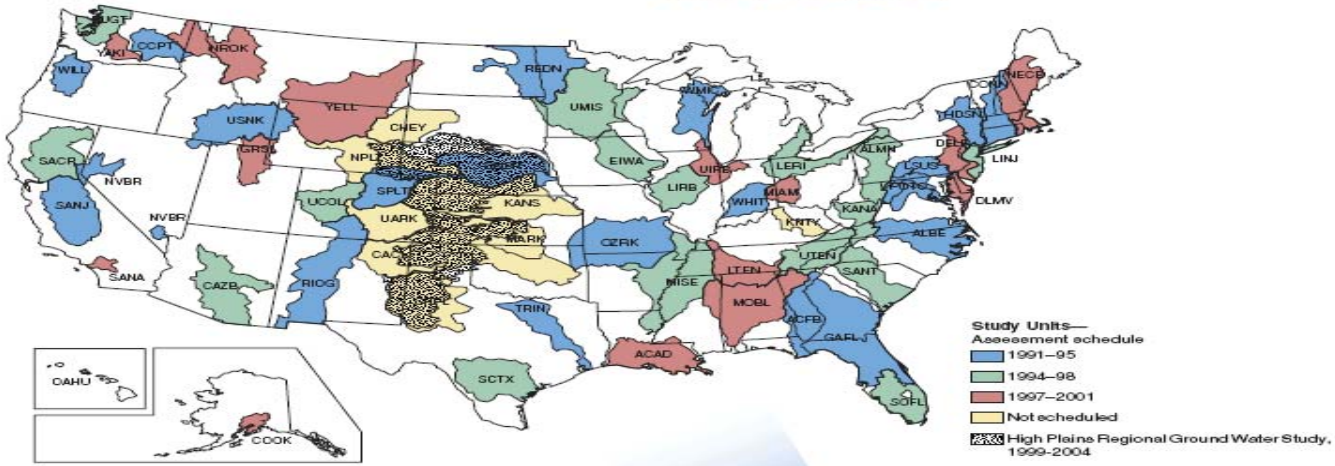
- Can correlate to long-term trends in environmental conditions
- Immediate measures of trend
- Makes use of natural integration over space/time
- Simultaneously evaluate many sediment-bound contaminants

Interpretation



NAWQA study units are reduced and consolidated for the second cycle of assessment

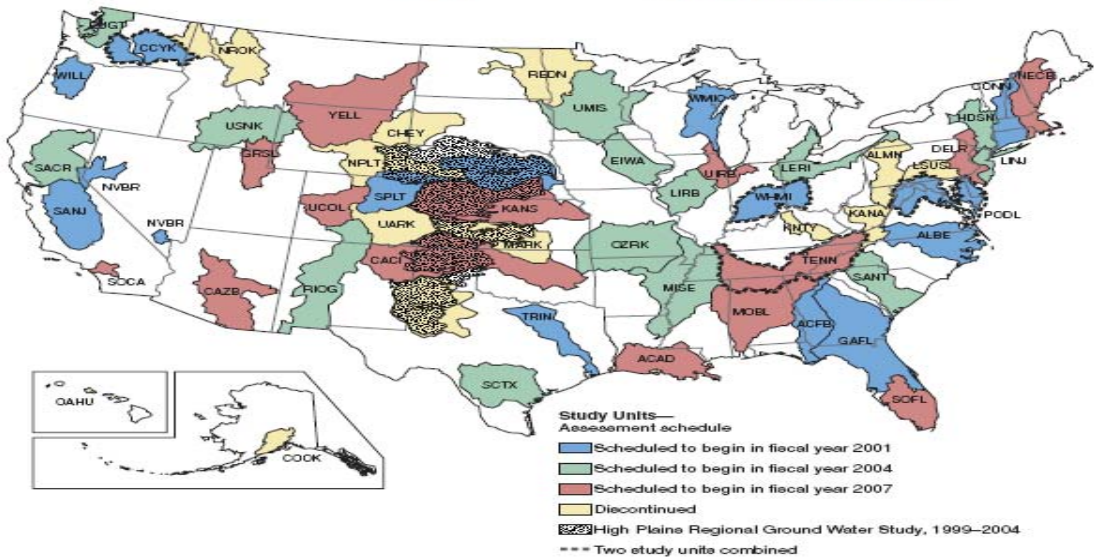
1991 to 2001



Study units in the second cycle

In the second cycle of studies, the NAWQA Program will focus on 42 of the Nation's most important river-basin and aquifer systems. The geographic scope of the original design (59 study units) has been adjusted to accommodate budget reductions. A systematic process was used to eliminate 13 study units and combine 8 into 4 study units. Geographic areas were selected to represent a wide range of important hydrologic environments and priority ecological resources; critical contaminant sources, including agricultural, urban, and natural sources; and a high percentage of population served by municipal water supply and irrigated agriculture. The 59 original study units covered about 65 percent of water used for drinking and irrigation; the reduced set of 42 study units still accounts for more than 60 percent of those water uses. This adjusted national study design supports the goal of extrapolating directly measured water-quality conditions to unmonitored, comparable areas in other parts of the Nation.

2001 to 2012



Second & Third phase (20^{th} – 30^{th} yrs)

- **Shift resources away from “status” goal**
- **Shift resources toward trends and explanations**
- **Shift toward regional interpretations**
- **Shift toward targeted large scale studies**
- **Gradually shift away from staging toward a more homogenous coverage**
- **Reduce number of independent study units as program becomes unified**

CONCLUSIONS

- Clear goals continuously useful
- Must be feasible: (i.e. can stage goals & coverage over time)
- Targeted vs. probabilitistic design
- Interdisciplinary but integrated
- Interpretation is critical
- Explicit, early decisions among tradeoffs facilitate long-term coherence

Spatial Analysis and its Role in Performance Measures

Paul E. Smith

Fisheries Resources Division
National Marine Fisheries Service
Southwest Fisheries Science Center
&
Integrative Oceanography Division
Scripps Institution of Oceanography
University of California San Diego

PM Workshop 2007

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Sacramento CA

Spatial Analysis and its Role in Performance Measures- Basics

- Science provides an approach to **testing** certain types of ambiguity
- A test results in falsifying one limb of an ambiguity
- Basic science performs by **recording** the elimination of an alternative [in time]
- Applied science performs by **recording** the probability of alternatives [best science]

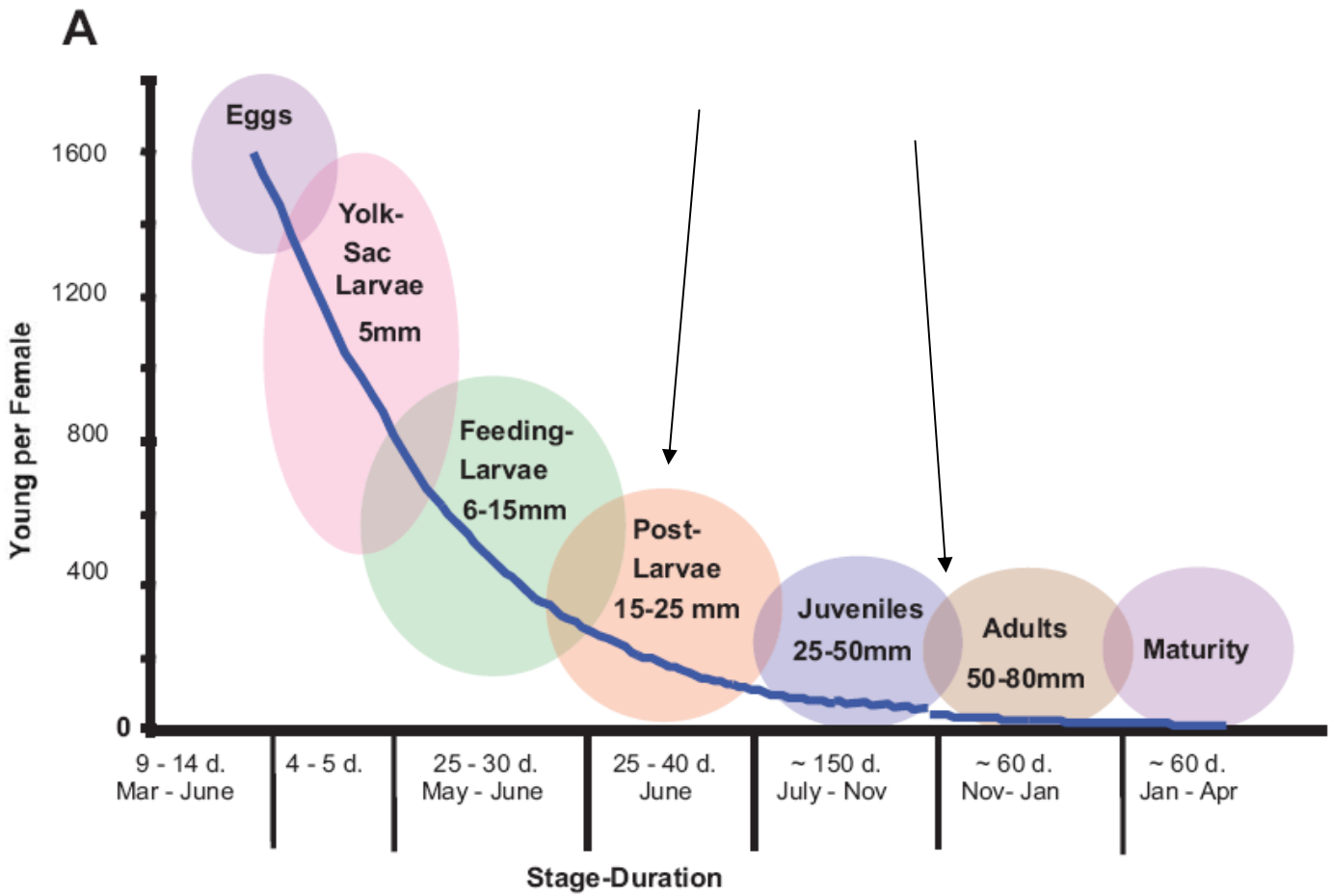
Performance Measures - Progress

- Conceptual Model
- Formulation and Selection of Alternatives
- Refining Alternatives into Tests
- Document Model, Selection, Test Results
- Highlight Ambiguities
- Reformulate

Estuarine Spatial Analysis Example

- Population has brackish turbid juvenile habitat
- Saline extremity may have different population limiting factors than fresh extremity
- Spatial moving window
- Salinity moving window
- Transparency moving window

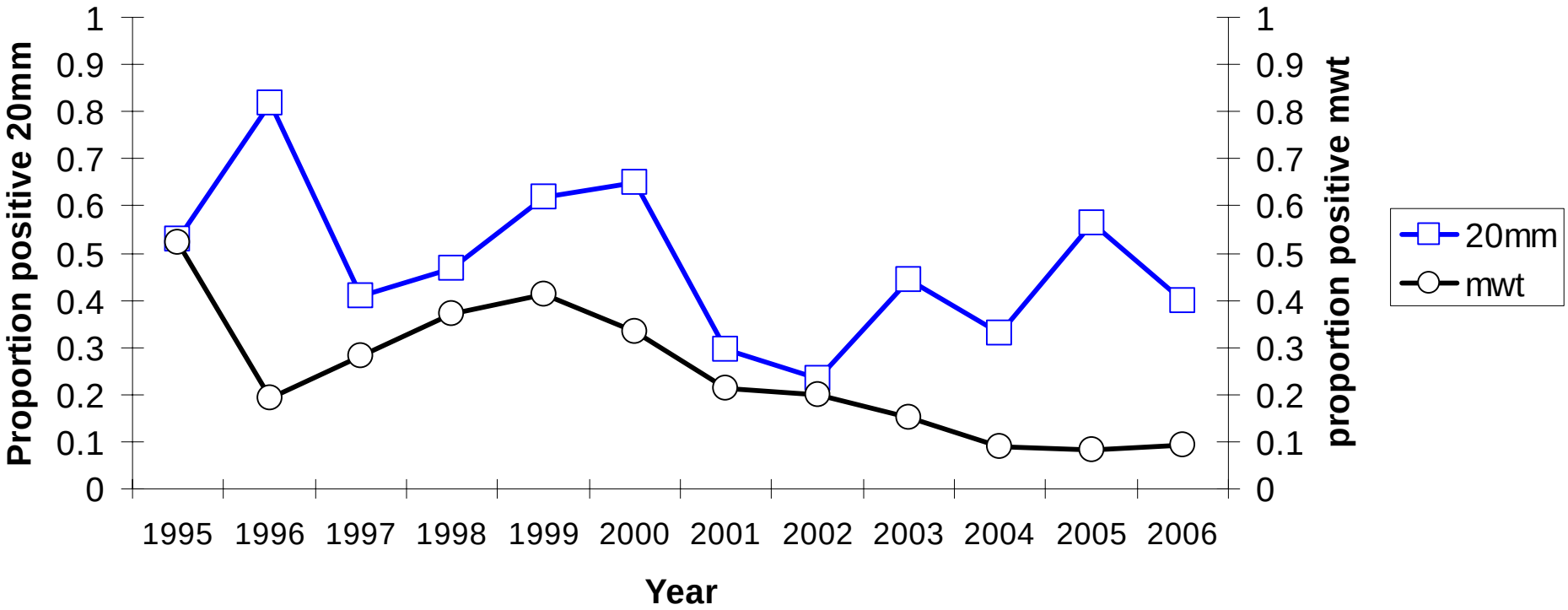
Bennett 2005 Delta Smelt Life Table Template



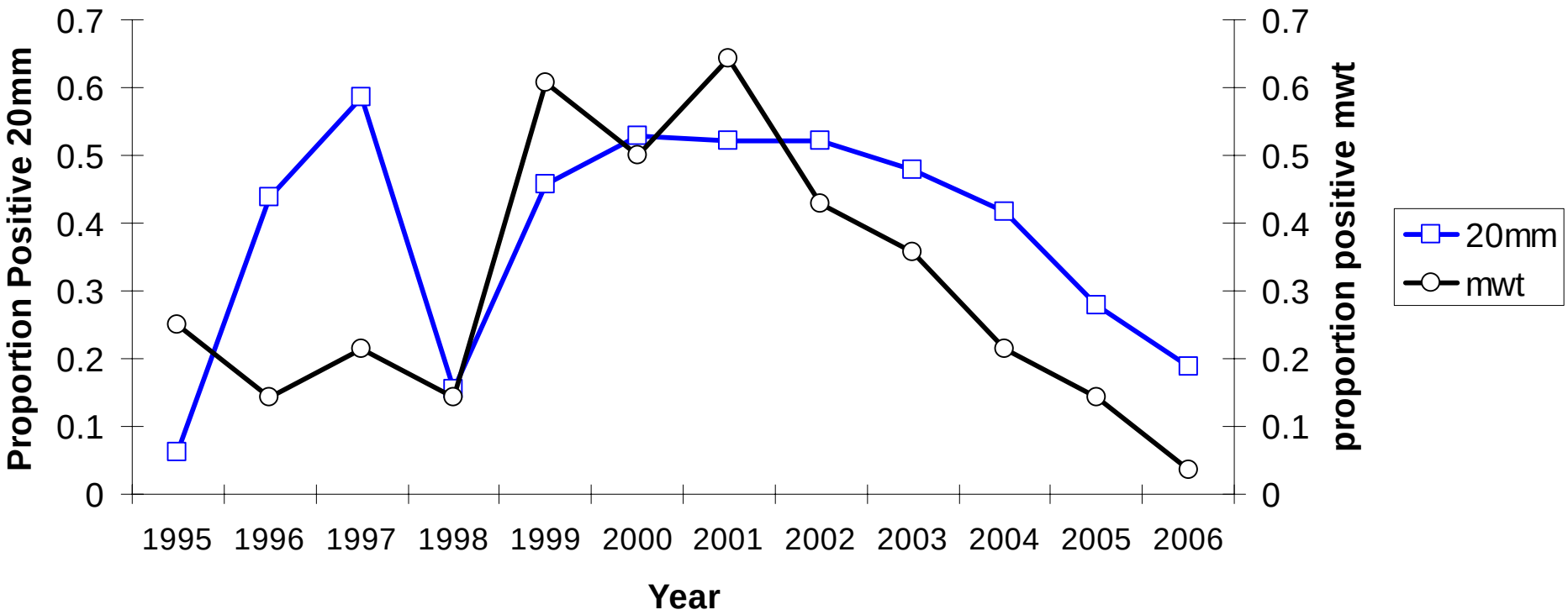
Graphic Example

- Ambiguity
  - Population is limited by larval supply
  - Population is limited by juvenile survival
- Static Survey Analysis
- Sample Design for Test

Delta Smelt Suisun



Delta Smelt North Delta



Performance Measures - Progress

- Formulation and Selection of Alternatives
  - **In terms of performance – this is where we are**
- Refining Alternatives into Tests
  - Moving Windows on Spatial and Environmental Base
  - Survey data are tautologous
  - Survey Data too sparse
  - Design and budget an augmented survey
  - Put documented proposal into the Field research queue
  - Spatial check of growth in Survey Sample Specimens
- Highlight Ambiguities
- Reformulate

Performance Measures – Summary

- In a boundary habitat, we may expect estuarine species to have strong spatial components. Performance measures should also be geared to relating populations to their several habitats
- Performance measures should consider implementation of new approaches based on habitat diversity elaboration within the conceptual model